"Additional Notes on Boulders and other Rock Specimens from the Newlands Diamond Mines, Griqualand West." By T. G. Bonney, D.Sc., LL.D., F.R.S., Professor of Geology, University College, London. Received November 21,—Read December 13, 1900.

The invasion of Griqualand at the beginning of the war with the Transvaal and Free State, put a stop, for a time, to working the Newlands Diamond Mines, some interesting specimens from which were brought to the notice of the Royal Society, on June 1st, in last year.* But shortly before the hurried departure of the employés, another small collection had been despatched to Mr. G. Trubenbach, the Managing Director in London, which he showed to me, early in the present year, most kindly placing the new specimens at my disposal for study. Some represented boulders, some the diamantiferous breccia, popularly called "blue ground," in which these occur; some the "country rock." The first, though (so far as can be seen) without diamonds, include at least four additional species of rock; the second throw a little more light on the past history of the matrix. Moreover, they come from a new set of workings to the north-east of the former, where a shaft has been sunk, and galleries driven at a depth of about 465 feet. Apparently two "pipes" are connected by a narrow fissure filled with breccia.† So I have ventured to communicate the result of my investigations to the Royal Society, including with them a short note on a residue obtained by Sir William Crookes, F.R.S., after dissolving away almost the whole of a small fragment of the remarkable diamantiferous eclogite which was described in June, 1899.

## (1.) *The Boulders.*

(*a.*) Of these one is rudely semi-oval in outline, measuring about $3\frac{1}{2}$ inches in greatest length and breadth, and $1\frac{1}{2}$ inch thick, being probably a piece broken from an ellipsoidal pebble. The rock is holocrystalline, composed chiefly of a pyroxene resembling bastite and of olivine, converted on the older-looking surfaces into a pale-green serpentinous material. Examination of a thin slice shows the rock to consist mainly of olivine, which exhibits incipient serpentinisation along cracks in the usual manner, and of a very pale brownish-green bastite, with one close cleavage; and possibly one or two small grains of a monoclinic pyroxene; spinel, and even original iron oxide, being apparently absent. Specific gravity, 3·074.

* 'Roy. Soc. Proc.,' vol. 65, p. 223.

† The precise depth at which the specimens were obtained cannot be given, as the labels became illegible in the hurried transit.

(*b*.) Another specimen, apparently about half of a fairly well-worn boulder, is not quite so large. Under the microscope it is found to be practically identical in composition, but a little more serpentinised; a clear isotropic mineral sometimes forming a border to the enstatite. The presence of any original grains of iron oxide is doubtful, but one or two of augite can be recognised. Both specimens, however, may be named Saxonites.

(*c*.) Not very much worn, and rather triangular in shape, about 3 inches by 1 inch, and about 0·6 inch thick, consisting apparently of garnet, two pyroxenes and perhaps olivine. Microscopic examination shows olivine, almost wholly converted into serpentine, enstatite partially changed to another (the usual) variety of the same mineral; chrome diopside, a little colourless augite, with a diallagic habit, and pyrope (two specimens). As the last-named mineral is not abundant, the rock is more nearly related to the Lherzolites than to the Eulysites, and so may be named a granatiferous Lherzolite.

(*d*.) A roundish flat slab about $3·5 \times 2·5 \times 0·6$ inches, containing red garnets, enstatite, and a bright green pyroxene. Microscopic examination shows olivine, partly converted into a dull yellowish-green serpentine, chrome diopside, some enstatite, now altered to a serpentine, the colour suggesting that it is chromiferous, and pyrope (not abundant). A little pale brown mica, probably secondary, occurs about the garnets and the diopside, in one case occupying a crack. The rock belongs to the granatiferous peridotites, and though it contains less enstatite than the last one, may also be regarded as a variety of Lherzolite.

(*e*.) The next specimen is evidently a fragment, the angles and edges of which have been slightly worn, as if by water. It measures about $3\frac{1}{2}$ by 3 inches, and $1\frac{1}{4}$ inch in thickness. The rock in the fresher part consists of pyrope, and two minerals of a dull-green colour, but about half of one surface is affected by decomposition, which has penetrated to a depth of about $\frac{3}{4}$ inch. Here one of the pyroxenic minerals appears to be a pale-coloured bastite with the usual metallic lustre; the other of a brighter green tint. Examination with the microscope shows the following minerals:—(1) Olivine in various stages of conversion into serpentine; some grains being traversed as usual by very pale-green strings of the latter mineral, others completely changed into it, and of a yellowish or brownish colour; minute dark-brown needles are sometimes present (? rutile). (2) Bastite with a well-developed pinacoidal cleavage; sometimes partially or even wholly converted into a fibrous material, which with transmitted light is a rather rich green colour, the usual small brown negative crystals being developed in some grains. (3) A very pale sea-green augite, probably a chrome diopside. (4) Pyrope; the grains having a kelyphite rim and showing incipient mineral change along the cracks.

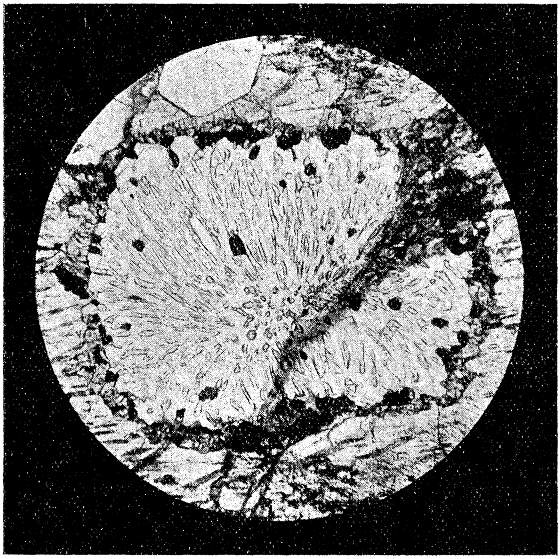
As one or two grains with a general resemblance to the bastite appear to give an oblique extinction, a third pyroxene may be present in very small quantities. Mica is wanting as an original constituent, and most of the iron oxide is secondary, but one grain may be primary. The structure of the rock is granular, no constituent being idiomorphic; hence the order of consolidation cannot be determined with certainty, but I incline to placing the olivine, which is slightly the most abundant mineral, first, and the garnet, which is slightly the least so, last. The rock is distinguished from ordinary Eulysite by the presence of a fair amount of an enstatite, but as this does not indicate any important difference in chemical composition, I prefer calling it Enstatite-Eulysite, to burdening petrology with a new name.

(*f.*) This specimen has a rude resemblance to an oven bottom loaf, measuring full 16 inches in two directions at right angles on the curved surface; the flat side being probably the result of a fracture, apparently produced after most of the rounding had been done. The rock is holocrystalline, its principal constituents being dull red garnets and green pyroxenes. The former have their outer surface worn smooth and flat, the latter a very slightly corroded one. The rock is macroscopically identical with the eclogite described in the last paper, and it proves to be composed of pyrope and chrome diopside with occasionally a few fibres of secondary hornblende, no grain either of olivine or iron oxide occurring in the slice.

(*g.*) This specimen is a rudely trapezoidal block with rounded edges and corners, measuring about $2\frac{1}{2}$ inches each way, apparently rather water-worn, consisting of somewhat rounded crystals of greenish pyroxene, over an inch in length, in a matrix of a similar mineral and felspar. Specific gravity, 3·125. On examination with the microscope, the larger grains prove to be generally diallage, a faint sea-green in colour, with a close pinacoidal cleavage, often made more distinct by the deposit of a little opacite or ferrite. Small brown negative crystals are frequent, one of their longer edges lying parallel with an axis of elasticity. This mineral is altered locally into a pleochroic hornblende (changing from a raw to a burnt umber tint). The diallage is sometimes bordered by, and near its edges occasionally encloses, small grains of a slightly browner and more pleochroic mineral, extinguishing parallel with its principal cleavage, and thus representing a rhombic pyroxene,* but it also throws out root-like prolongations in which a cross cleavage is visible. Where the diallage has been replaced by hornblende, the latter often extends some little distance into the roots, which in a few cases suggest the presence of the rhombic constituent. These are embedded in felspar, thus affording a pegmatitic structure which varies in different parts of the slices from incipient to well

* These locally are seen to pass into a yellowish serpentinous mineral, which with crossing nicols shows a fibrous structure and fairly bright polarisation tints.

developed (see figure). Some of the larger diallage crystals also show a curious structure with crossed nicols; small lamellæ of a different tint, arranged in a kind of network with lozenge-shaped meshes, making



Pegmatitic association of a pyroxene and felspar (composite). × 21. The "rootlets" and most of the mineral round the central grain is pyroxene. Decomposition shown about a crack.*

their appearance. These possibly may indicate an early stage of the conversion of the diallage into hornblende. The grains of felspar vary much in size, even when associated with the "rootlets" of pyroxene. They are generally in good preservation; exhibit twinning, usually on the albite type, and are shown by the extinction angles to be mostly if not wholly labradorite. Small grains of iron oxide are present, which are most abundant near the margin of the larger pyroxenic grains. They are sometimes scattered in the pegmatite, and in one or two cases are slightly root-like in shape. Cracks traverse the rock and have led to mineral change. They are often lined with small crystals of a brown mica, similar to that which occurs in some specimens of the "blue ground." These are imbedded in a rather earthy-looking granular material, which is, no doubt, a decomposition product from the felspar. Pegmatitic structures, whether macroscopic or microscopic, are fairly common in granites, where the associated minerals are quartz and felspar, but, so far as my experience goes, are infrequent with other minerals.

* I am indebted to my friend Mr. Coomára-Swámy for the microphotograph.

Professor Rosenbusch however mentions the occurrence in some syenites (including those with elæolite), in diorite (very rare), and in a hypersthene gabbro (or norite) from Ekersund, on the west coast of Norway, and St. Paul's Island, Labrador.* Thus we may be content to call this rock a pegmatitic hornblendic Gabbro.

(*h*.) This perhaps represents a pebble rather than a boulder, for it is a fragment only about $1\frac{1}{2} \times 1\frac{1}{2} \times 1$ inches, adhering to a piece of "blue ground," the surface in contact with the latter being well rounded. Macroscopically it appears to be a medium-grained diorite; the microscope shows a holocrystalline granular structure; the plagioclastic felspar is in fair preservation, and, perhaps, is labradorite; the hornblende is rather strongly pleochroic, ranging from pale brownish-green to deep brown. The mineral, however, is not original, but an alteration product from a pale green augite (omphacite?). Grains of iron oxide are also present. Slight decomposition has taken place in a narrow zone from the surface inwards.

(*i*.) The last specimen is a lump of irregular shape. Presumably it is from the blue ground, but there is nothing to prove this. In a compact dark brown to slightly purple ground-mass, a number of irregularly-formed greenish-grey patches are scattered so as to suggest flow brecciation. These, when examined under the microscope, are a very light greyish-brown in colour, exhibiting flow structure, minute devitrification, and some decomposition. The matrix is darker, sprinkled with opacite and ferrite, minutely devitrified, showing an irregular wavy structure, and occasionally ill-defined crystallites of plagioclase felspar. The rock, now a felsite or porphyrite, was probably once either a sanidine trachyte or more probably an andesite, with flow brecciation. This specimen possibly may not represent a boulder, but a dyke or flow associated with the "blue ground."

### (2.) *Diamantiferous Matrix.*

Specimens of the "blue ground" in which the boulders occurred were also sent. As they came from another part of the mine, and the best preserved exhibited one or two slight differences, I have had a few slices prepared. To the unaided eye the matrix is more of a purple-brown colour, slightly more compact and hard, but more brittle; the fragments of magnesian minerals, however, seeming more completely serpentinised. A few small, rather crumbling, rock fragments,

* 'Elemente der Gesteinslehre' (1898), p. 221. A case where the structure is more like that of the true graphic granite, from the dolerite of Pouk Hill, is described by Mr. Allport, 'Quart. Journ. Geol. Soc.,' vol. 30, p. 549, and figured by Mr. Teall, 'British Petrography,' Pl. XXIII, fig. 2. An instance of micrographic intergrowth of quartz and calcite is described by Mr. Coomára-Swámy in the aforenamed journal, vol. 56, pp. 605, 606.

of a dull white colour, speckled with green, are present. Microscopic examination shows that the larger minerals do not call for any special notice, except that a rudely crescentic pyrope has a kelyphite rim on the concave as well as on the convex side, proving the fracture to be an old one. But the small plates of a brown mica, the occurrence of which has been already noticed,* are very abundant in the matrix. These plates in some of the specimens are rather irregularly outlined, and rarely exceed 0·001 inch in diameter, but in others they average about double that size, and occasionally a few of them may even exceed 0·004 inch. Then the outline is more rectangular, and the cleavage more distinct. The smaller flakes often tend to form a zone around included rock fragments, and scattered granules of iron oxide seem more common in the slices containing the larger flakes.† I have now no doubt that the mineral is a secondary product.

The unusual abundance of a minute brown mica in the ground mass made an analysis desirable. For that annexed I am indebted to Mr. C. James, who has executed it in the laboratory at University College under the supervision of Professor W. Ramsay.

| | |
|---|---|
| Silica | 38·77 |
| Alumina | 14·62 |
| Ferric oxide | 11·36 |
| Calcium oxide | 4·51 |
| Magnesia | 12·14 |
| Potash | 2·63 |
| Soda | 1·90 |
| Loss on heating $CO_2$ and $H_2O$ | 13·55 |
| | 99·48 |

(The iron was all estimated as $Fe_2O_3$; one specimen gave a trace of nickel.)

If we compare this analysis with one given by Professor C. Lewis,‡ $SiO_2 = 33·00$, FeO (including $Al_2O_3$) $= 12·00$, $MgO = 32·38$, $CaO = 0·63$, $Na_2O = 0·67$, $CaCO_3 = 16·02$, $H_2O = 6·0$ (total 101·71), and with those of Kentucky "kimberlites" quoted by Rosenbusch,§ and by Lewis,|| we see them to be poorer in alumina and alkalies, but richer in magnesia. Serpentine, in fact, forms the dominant silicate in them, a ferro-magnesian mica in this, the other mineral not amounting at most to a quarter of the whole rock. But we must remember

* 'Geol. Mag.,' 1897, p. 451.

† In all these specimens from Newlands opaque granules (? ilmenite) seem to take the place of the translucent brownish granules (in part perofskite) in the specimens from De Beers Mine.

‡ 'The Matrix of the Diamond,' p. 47.

§ 'Elemente der Gesteinslehre,' p. 165.

|| 'The Matrix of the Diamond,' p. 64, *cf.* p. 61.

that some of the deeper-seated specimens from the De Beers Mine, though belonging to the typical mass of kimberlite, are hardly less rich in the secondary mica than this one from Newlands, so that from the chemical point of view, apart from other considerations, the propriety of classing "kimberlite" with the (altered) peridotites is worse than doubtful.

The rock fragments are often about 0·1 inch in diameter, though pieces nearly half an inch across also occur, sub-angular to rounded in form. The majority represent varieties of basalt, some apparently retaining traces of a glassy base, others rather minutely holocrystalline. They show signs of alteration, but nothing in their structure or composition calls for any detailed description. It is difficult to determine the exact nature of the light-coloured fragments. The green mineral is sometimes a granular augite, rather decomposed, sometimes an actinolite; the lighter (dominant) part often effervesces briskly with HCl, and calcite is seen under the microscope, associated with a grey decomposition product, which often suggests the former presence of a felspar. In one case a holocrystalline granular structure is clearly seen, and the replacing mineral has some resemblance to pseudophite. Hence I consider these fragments to represent a plagioclase-augite rock allied to gabbro, and related to the boulder already described. Its presence, and the comparative abundance of bits of basaltic rock, seem to be characteristic of the locality.

One specimen, however, calls for a little notice. Part of it resembles a compact mudstone; the rest, about an inch across, is rather decomposed blue ground; the outer side of this suggesting that, as in the case of a specimen described last year, the "blue ground" may occupy a fissure in the "country rock." On microscopic examination, however, this proves to be doubtful. The apparent outer surface is only a vein product, consisting of a fibrous mineral, possibly arragonite, associated with a little actinolite. The seeming mudstone is more like a very decomposed igneous rock, probably a rather felspathic basalt. The "blue ground" is also much decomposed, the mineral fragments being converted into a pale greenish-yellow fibrous material, much of which is actinolite. A fragment of basalt (not identical with the other) appears to be altered for a depth of not quite one-tenth of an inch from the exterior, for in this part small distinct flakes of brown mica are scattered about.

The specific gravity of a specimen of "blue ground," rather harder than the rest, was 2·667; two others, representing the most brittle variety, were weighed, but as each crumbled a little when immersed, the results are slightly too low. One (the better) was 2·622, the other 2·614. I tried the former a second time, but as it broke up more readily than before, abandoned the attempt.

I referred last year to a pyrope in which diamonds were embedded.

Another specimen has now been found. The pyrope apparently was rounded in form, about a $\frac{1}{4}$ inch in diameter, and surrounded by a kelyphite rim. It is broken across, thus disclosing the diamond, an octahedron, only one face of which is completely exposed. This is slightly stepped, and measures roughly one-tenth of an inch along the edge. A small piece of the usual purplish breccia adheres to the pyrope, so the case is exactly parallel to the former one. In each the perfect form of the diamond shows that it crystallised before the garnet, and as the ordinary varieties of the latter mineral seem to be produced at a high temperature,* the association may be significant.

### (3.) *The Country Rock.*

A few specimens of this were also sent, but only two varieties present any feature of interest. One is a greenish conglomerate with calcareous matrix, and rounded pebbles up to about $\frac{1}{4}$ inch diameter; the other has a pale-grey matrix, speckled with some small angular dark-green fragments and a few sub-angular pebbles up to about an inch in diameter; one apparently a red felsite, the others diabase. In the first specimen the microscope shows abundant sub-angular to rounded grains, mostly diabase, of which there are at least half a dozen varieties, a microgranite and two or three rocks more fragmental in aspect; one perhaps a tuff, another apparently a quartzite, affected by pressure, and a third a sub-crystalline dolomite. These are cemented by microgranular calcite, containing probably a little magnesia (the crystals often forming a kind of border to the rock fragments), the interspaces being filled in with clear dolomite. In this cement are embedded some angular bits of quartz, a fragment of altered felspar, and one or two, perhaps, chalcedony. The other specimen shows a fine-grained muddy matrix, in which are scattered angular to sub-angular grains of quartz, with a little decomposed felspar, a little of a green mineral (? replacing pyroxene), decomposed iron oxide, and perhaps some small rutiles, with rock fragments, generally rather rounded, representing compact diabase, or possibly sometimes andesite, and one or two of a sub-crystalline limestone. Both these specimens, as Mr. Trubenbach informs me, represent a rock named "bastard blue" by the miners, and it has been pierced in both shafts, the diamantiferous breccia, or "blue ground," apparently passing under it in the second shaft. As, however, there is no real relationship between the two rocks, I regard the association as fortuitous.

* I do not forget the remarkable garnets from the Bastogne, described by Professor Renard ('Bull. du Musée Royal de Belgique,' vol. 1, p. 9), or that called pyreneite (also one of the andradite group), but both these minerals are very abnormal. [The genesis of the former is discussed by Miss C. A. Raisin, D.Sc., in a paper which will appear in the 'Quarterly Journal of the Geological Society' for 1901.]

### (4.) *Residue from the Diamantiferous Eclogite.*

After the reading of my description of the "diamantiferous eclogite," Sir W. Crookes kindly offered to examine that rock for microscopic diamonds. Taking one of the fragments, weighing 130·5 grammes, which had been detached in slicing the specimen, he treated it as follows :— "After being very coarsely broken up, the material was put into a very strong sulphuric acid. The acid was boiled for some time, and, after being allowed to cool, the residue was washed, dried, and then heated for some hours in strong hydrofluoric acid. After it had been well washed and dried the treatment with hot sulphuric acid was repeated. The mass, after a few alternations of these acids, became disintegrated, and all, except a few crystalline lumps, were dissolved. After about ten treatments only a few small crystals remained, and these (with the exception of a sample) were reduced by a few more boilings with the acids to a single small one about half a millimetre in diameter." This was boiled fourteen times in each acid, and appeared to be slightly reduced in size. "It sinks in methylene iodide, specific gravity 3·35." This was sent to me with some of the small crystals just mentioned, all being mounted. The solitary survivor of the whole treatment showed on one side curved crystal faces, but on the other appeared imperfect. These faces, so far as I could judge, indicated an isometric or possibly a rhombohedral mineral. Its refractive index is high, the colour a pale smoke-brown, and it apparently produced some effect on polarised light. That, however, was not conclusive, for diamonds from Newlands, as at Kimberley, are often in such a state of strain as to be anisotropic. Of the survivors of the first treatment, the more abundant were colourless, rough in outline, but possibly showing one cleavage surface, apparently at right angles to an optic axis; polarisation tints bright; the refractive index high, but inferior to that of a diamond. It appeared to me not improbably corundum. The less abundant granules were more rounded in outline, with rather rough, possibly corroded, surfaces, translucent, of a resin-brown colour, apparently producing some effect on polarised light; on the whole they seemed to bear some resemblance to rutile. But to come to any conclusion about the first mineral it was necessary to detach it from the mount. As I have no apparatus for very delicate work, that not coming within my usual line of study, I had recourse to Mr. L. Fletcher, the Keeper of Mineralogy, and Mr. L. J. Spencer, also of that Department, at the British Museum. The latter attempted to measure the supposed diamond with the goniometer; the faces, however, were too curved for the purpose, but both of them regarded the edges as too sharp for the mineral to have suffered appreciably from the acid, as Sir W. Crookes was inclined to think. They consider it to be really iso-

tropic, and a diamond.* Mr. Spencer thinks that the colourless birefringent fragments are perhaps optically uniaxial, and that they may very well be corundum.† The browner grains he suggests are also diamonds. In favour of this identification is the fact that small diamonds occur at the Newlands Mine (I have seen some in Mr. Trubenbach's hands), rather ovoid in shape, with a roughened surface, some a yellowish-brown, some colourless. But against it we may urge that they appear to have been destroyed during the second treatment.‡ Be this as it may, Sir W. Crookes has succeeded in showing that microscopic diamonds do occur in the eclogite, which contains those of larger size.

To conclude: in addition to this residue from the eclogite we have ascertained (1) the existence, in some quantity and variety, of pretriassic diabase,§ (2) the abundant development of a microscopic brown mica in the ground mass of the so-called kimberlite; (3) the presence in it, as true boulders, of at least four more species of holocrystalline rock. The last fact acquires an additional importance, because, since the publication of my former paper, the boulders therein described have been claimed as "concretions" in the so-called kimberlite.‖ With this matter I have dealt elsewhere,¶ but the identification of seven species or strongly-marked varieties of holocrystalline rocks, peridotites, eclogites, &c., in which the minerals at the surface are worn as if by the action of water, not to mention the general structure of the so-called kimberlite, must, I think, offer insuperable difficulties even to the most enthusiastic advocate of concretionary action.

---

# "The Distribution of Vertebrate Animals in India, Ceylon, and Burma." By W. T. Blanford, LL.D., F.R.S.

Received December 3,—Read December 13, 1900.

(Abstract.)

Several contributions on the subject of the distribution of Vertebrata, or geographical Zoology, in India and the neighbouring countries

* On re-examining the specimen, now that Mr. Spencer has kindly mounted it in a better position, I agree with this determination.

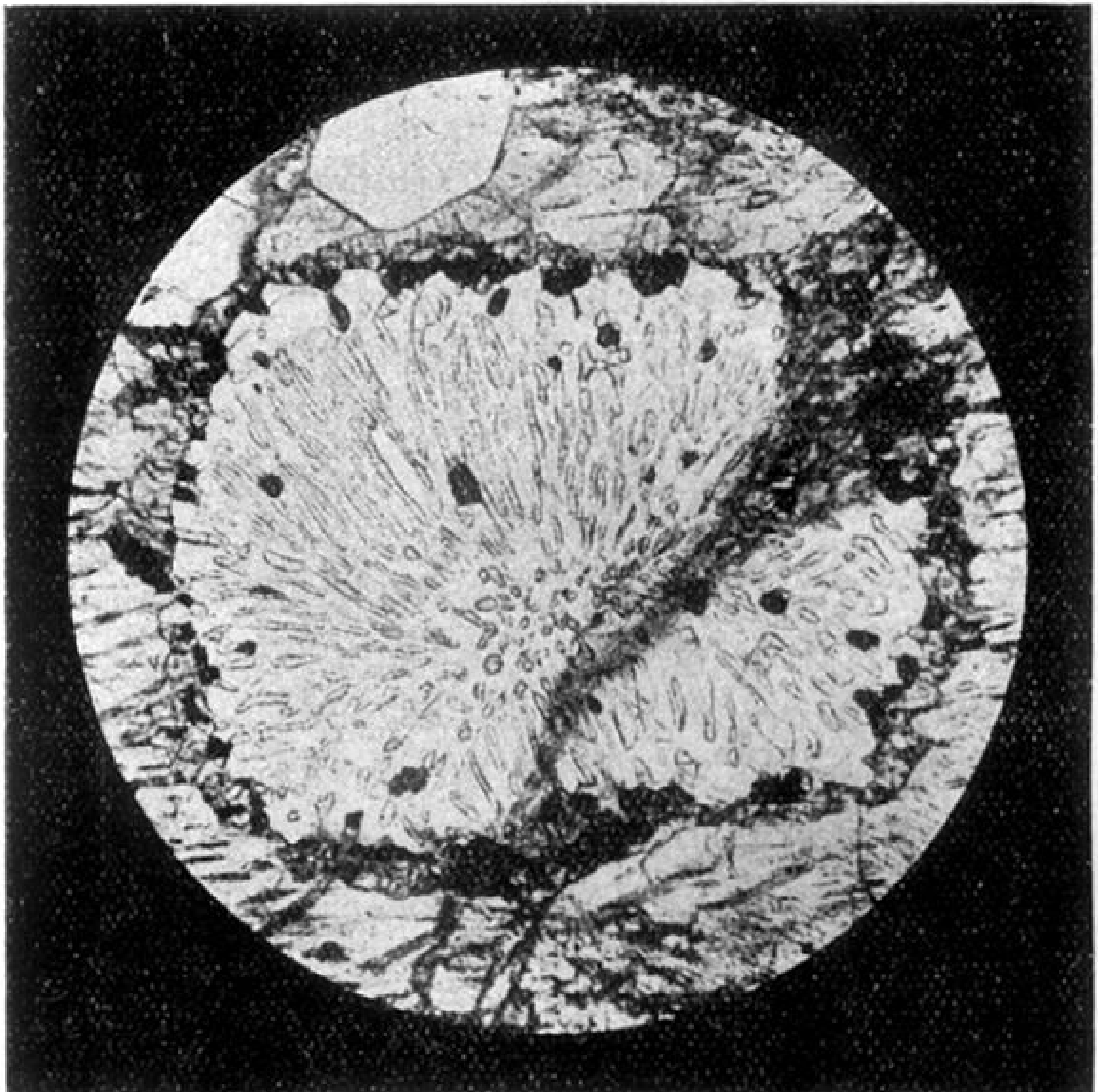
† On a final examination of the slides, I find among them one if not two small grains which I strongly suspect to be diamonds.

‡ A final examination and comparison with some bits of "bort" given me by Mr. Trubenbach has not made me more favourable to my original identification with rutile.

§ That is, at any rate, older than the time when the Karoo series was deposited.

‖ Professor Beck, 'Zeitschrift für Praktische Geol.,' December, 1899.

¶ 'Geol. Mag.,' 1900, p. 246.



Pegmatitic association of a pyroxene and felspar (composite). × 21. The "rootlets" and most of the mineral round the central grain is pyroxene. Decomposition shown about a crack.*